Questions are for both separate science and combined science students unless indicated in the question

Q1.

This question is about electrolysis and the extraction of metals.

(a) Why can some molten substances be electrolysed?

Tick (✓) **one** box.

Electrons can move through the molten substance to the electrodes. ☐

Ions can move through the molten substance to the electrodes. ☐

Protons can move through the molten substance to the electrodes. ☐

(1)

(b) The table below shows the products of the electrolysis of some molten compounds.

Complete below table.

Molten compound	Product at negative electrode	Product at positive electrode
Lead chloride	_____	Chlorine
Potassium iodide	Potassium	_____
_____	Zinc	Bromine

(3)

Aluminium is extracted by electrolysing molten aluminium oxide.

(c) Balance the equation for the reaction.

Choose numbers from the box.

2	3	4	5

$$2\ Al_2O_3 \rightarrow \_\_\_Al + \_\_\_O_2$$

(2)

(d) Calculate the relative formula mass (M_r) of aluminium oxide (Al_2O_3).

Relative atomic masses (A_r): O = 16 Al = 27

_____

_____

_____

Relative formula mass (M_r) = _____

(2)

(e) The figure below shows part of the reactivity series of metals.

The non-metal carbon has been included.

Metals can be extracted from their compounds by:

- electrolysis
- reduction with carbon.

Electrolysis is more expensive than reduction with carbon.

Predict one metal that would be extracted by each method.

Use the figure above.

Extracted by electrolysis _____

Extracted by carbon reduction _____

(2)

(Total 10 marks)

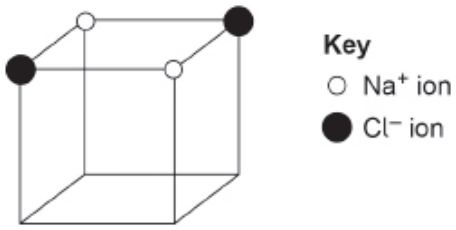
Q2.

This question is about ionic compounds and electrolysis.

Sodium chloride is an ionic compound.

(a) **Figure 1** represents part of the structure of solid sodium chloride.

Figure 1



Complete **Figure 1**.

(2)

(b) Give **one** reason why molten sodium chloride conducts electricity.

Refer to ions in your answer.

_____

_____

(1)

(c) The table below shows products of the electrolysis of two molten ionic compounds.

Complete the table.

Molten compound	**Product at the negative electrode**	**Product at the positive electrode**
Magnesium bromide	Magnesium	_____
Potassium chloride	_____	Chlorine

(2)

(d) Aluminium is extracted by electrolysis.

The electrolyte is a molten mixture of aluminium oxide and cryolite.

Why is a mixture used instead of pure aluminium oxide as the electrolyte?

Tick (✓) **one** box.

The mixture has a lower melting point than pure aluminium oxide.	☐
The mixture has the same melting point as pure aluminium oxide.	☐
The mixture has a higher melting point than pure aluminium oxide.	☐

(1)

(e) Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

What is the source of the hydrogen and the oxygen produced during the electrolysis of aqueous sodium sulfate solution?

Tick (✓) **one** box.

Air	☐
Sulfate ions	☐
Water	☐

(1)

Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

(f) Why is hydrogen produced instead of sodium in the electrolysis of aqueous sodium sulfate solution?

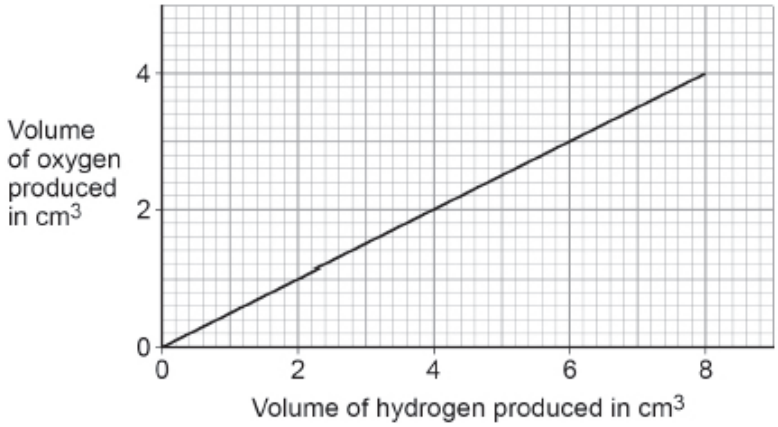
Tick (✓) **one** box.

Hydrogen is less reactive than sodium.	☐
Hydrogen has the same reactivity as sodium.	☐
Hydrogen is more reactive than sodium.	☐

(1)

(g) **Figure 2** shows the relationship between the volume of hydrogen and the volume of oxygen produced during the electrolysis.

Figure 2



Give **one** conclusion that can be made about the volume of hydrogen produced compared to the volume of oxygen produced.

_____

_____

(1)

(Total 9 marks)

Q3.

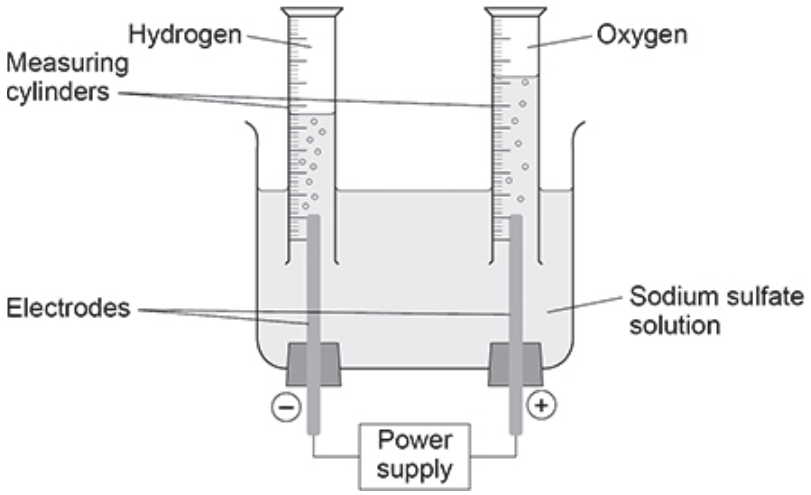
This question is about electrolysis.

Ionic compounds decompose when they are electrolysed.

A student electrolyses sodium sulfate solution.

Figure 1 shows the apparatus used.

Figure 1



(a) Sodium sulfate solution contains:

- hydrogen ions
- hydroxide ions
- sodium ions
- sulfate ions.

Oxygen is produced at the positive electrode.

Which ions are discharged at the positive electrode to produce oxygen?

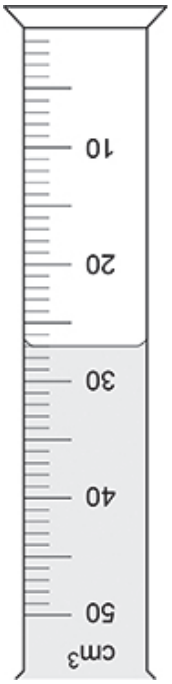
Tick (✓) **one** box.

Hydrogen ions	☐
Hydroxide ions	☐
Sodium ions	☐
Sulfate ions	☐

(1)

(b) **Figure 2** shows one of the measuring cylinders during the electrolysis.

Figure 2



What is the volume of gas in the measuring cylinder?

Volume of gas = _____ cm^3

(1)

(c) Ionic compounds can be electrolysed when molten or dissolved in water.

Why can ionic compounds **not** be electrolysed when solid?

You should answer in terms of ions.

_____

_____

(1)

(d) The table below shows the products of electrolysis of two molten compounds.

Molten compound	**Product at negative electrode**	**Product at positive electrode**
Potassium iodide	Potassium	_____
Zinc bromide	_____	Bromine

Complete the table above.

(2)

(e) The electrolysis of molten sodium chloride is used to extract sodium metal.

Why is sodium metal extracted by electrolysis instead of by reduction with carbon?

Tick (✓) **one** box.

Carbon conducts electricity. ☐

Carbon is less reactive than sodium. ☐

Carbon reduction uses more energy. ☐

(1)

(f) What is the state symbol for molten sodium chloride?

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

(1)

(g) Titanium can be produced from titanium oxide by electrolysis.

The equation for the reaction is:

$$TiO_2 \rightarrow Ti + O_2$$

Calculate the percentage atom economy for the production of titanium from titanium oxide by electrolysis.**(chemistry only) (HT only)**

Use the equation:

$$\text{Percentage atom economy} = \frac{\text{Relative atomic mass of desired product}}{\text{Relative formula mass of reactant}} \times 100$$

Relative atomic mass (A_r): Ti = 48

Relative formula mass (M_r): TiO_2 = 80

_____

_____

_____

_____

Percentage atom economy = _____ %

(2)

(Total 9 marks)